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SCIENCE & TECHNOLOGY

CHINA: ENERGY

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STRUCTURE, DEVELOPMENT OF ENERGY RESOURCES REVIEWED

40130023 Beijing ZHONGGUO DIZHI [CHINA GEOLOGY] in Chinese
No 11, 13 Nov 87 pp 20-23

[Article by Ma Xuechang [7456 1331 2490] of Department of Geology and Mineral Resources, Ministry of Geology and Mineral Resource: "A Discussion of China's Energy Resource Structure and Energy Resource Development and Utilization, With Suggestions for Energy Resource Mineral Exploration"[1]]

[Excerpts] I. The Current Situation in Energy Resource Production in China

During the Sixth 5-Year Plan, energy resource production increased by an average yearly rate of 6 percent. Gross output in energy resource production was 855.38 million tons[2] of standard coal in 1985. This included 870 million tons in raw coal output, 124.79 million tons of petroleum, 12.86 billion m^3 of natural gas and 407.3 billion kWh of electricity. Per capita consumption of energy resources was 0.7 tons/year of standard coal, less than the world per capita energy consumption figure of 1.6 tons/year. The discrepancy is even greater compared with the industrially developed nations. Coal dominates China's energy resources, while oil and gas dominate in the Soviet Union and the United States (Table 1). Barring major changes in the structure of energy consumption in China, forecasts are that raw coal demand will be 1.4 billion tons in the year 2000 and 2.5 billion tons in 2020. By that time, we will be facing the two main problems of transportation and environmental pollution. About 70 percent of China's coal reserves are concentrated in an energy resource base area centered around Shanxi. About 200 million tons of coal are being shipped out of the area each year now, and they tie up more than 40 percent of China's transportation capacity. Moreover, there are overstocks in producing areas and preliminary estimates are that 500 million tons [4] will have to be shipped out of the area by the year 2000 and that 1 billion tons will be shipped out in 2020. The Daqin Line now

under construction consumes enormous amounts of energy and will have a yearly transport capacity of 100 million tons, so it will be difficult to solve transportation problems. Some 84 percent of China's coal output is consumed through direct combustion. In 1980, 600 million tons of coal were produced and their burning produced 15 to 18 million tons of SO_2 and 20 million tons of ash. Acid rain has appeared in the south and environmental protection issues will become even more serious if this does not receive attention.

Table 1. Comparison of Energy Consumption Structures in China, the World, the United States, and the Soviet Union in 1984 (in percent) [3]

Country	Energy Resource					
	Coal	Petro-leum	Natural gas	Hydro-power	Nuclear	Other
China	75.1	17.7	02.3	4.9	---	---
World	30.3	39.5	19.6	6.7	3.9	---
United States	23.4	42.1	24.4	5.1	4.8	0.2
Soviet Union	25.3	36.2	34.4		1.8	2.3

II. The Situation in Energy and Mineral Resource Surveys

China has done a great deal of surveying for coal, petroleum and uranium ore since the nation was founded, and adequate attention also has been given to natural gas in recent years. The data obtained during more than 30 years of work now make it possible to evaluate primary energy minerals.

China is one of the richest nations in the world in coal resources. Predicted reserves buried at vertical depths of less than 1,500 m (1,000 m in south China) total 3.2 trillion tons[5] and reserves of more than 750 billion tons had been proven by 1985 (ZHONGGUO DIZHI [China Geology], No 5, 1986). At a recovery rate of 50 percent (without consideration of extraction and transportation conditions or degree of exploration) and calculating at yearly extraction of 1.5 billion tons (870 millions tons in 1985), China's existing coal reserves are sufficient for 240 years of extraction. If consideration is given to reserves which have been predicted but which cannot be explored, the years of service would be even longer.

China has been closely concerned with petroleum exploration and more than two-thirds of the area capable of producing oil has been surveyed. Substantial achievements have been made in petroleum geology work and several large oil fields have been discovered. This has enabled self sufficiency and petroleum is even being exported to earn foreign exchange. China has 2.48 billion tons of proven (extractable) petroleum reserves, 11th place in the world (according to date in the 1987 ZHONGGUO DIZHI BAO [China Geology Report]). Extrapolated using the 1985 petroleum output figure of 125 million tons, extraction could continue for 20 years. The main task now is to discover predicted resources and develop and utilize them economically. During the Sixth 5-Year Plan, growth in petroleum reserves in China has come mainly from the use of new parameters for recalculation of reserves in old oil fields. This means that the increase came through new oil pools discovered in old oil provinces. Increases reserves in new oil provinces accounted for a very small proportion. It is apparent from this that extremely difficult tasks face geological work in searching for new oil regions and new oil fields to assure stable growth in petroleum reserves and meet the needs of development in the petroleum industry.

World proven natural gas reserves at the end of 1986 totaled 102.6 trillion m^3. China is 17th in the world in natural gas reserves (according to data in the 1987 ZHONGGUO DIZHI BAO), and proven reserves amount to less than 0.5 percent of total world reserves. Sichuan Province has the best prospects for natural gas resources and output in China, and accounts for one-half of China's natural gas output. At 1985 output levels, China's proven and extractable natural gas reserves could be used for 11 years.

If converted to caloric power, surplus extractable reserves of petroleum and natural gas are equivalent to only 2.3 percent of surplus coal reserves. The reserves of petroleum and natural gas that may be found are equivalent to only 2 to 4 percent of discoverable coal reserves.

It is apparent from all of the above and an analysis of China's present energy resource mineral structure that the conditions do not exist to change the dominance of coal in China's energy resource structure to the dominance of petroleum and natural gas as in the United States and the Soviet Union. Analysis of China's national conditions also shows that it is not feasible for us to be like Japan, which imports large amounts of petroleum and liquefied natural gas.

III. The Prospects For China's Petroleum and Natural Gas Resources

The Tarim is China's largest basin. It covers 560,000 km^2, compared with only 260,000 km^2 in the Songliao Basin, which is the site of the Daqing oil field. The North China Platform, the Yangzi-Huai Platform and the coastal continental shelf were affected by Yanshan movement and have been fractured into several small blocks. Tectonic activity and magmatic activity not only affected Paleozoic oil and gas generating strata but also had direct effects on Cenozoic oil and gas producing strata. Moreover, the porosity and permeability of the sedimentary rock are rather low. In existing oil fields, heavy oil makes up a substantial proportion, and there is very little light oil and natural gas, indicating that the lighter components already have been lost. Analysis of the mineralization geology conditions of oil and gas resources shows that China cannot be compared with the Soviet Union and the United States. No large oil and gas fields have been discovered to date in the Asia-Pacific region.

Oil and gas exploration is a very difficult scientific and technological problem, and it requires that substantial funds be spent. Oil and gas exploration often has involved considerable risky "whateveristic accomplishing things in one move" thinking and a psychology of trusting luck and leaving things to chance which are harmful. We should, therefore, gain wide ranging data based on China's geological mineralization conditions and meticulously carry out concrete analysis and broadly adopt modern science and technology to take action and open things up. This will require a rather long time, however.

IV. Suggestions for Developing Energy Resource Production in China

First, we should strive as much as possible to convert some coal into gas and oil to obtain a cleaner energy resource, facilitate shipping, and increase utilization efficiency.

Coal gasification and liquification have been studied internationally and attacks have been made on key technical problems. The economic returns depend on local conditions and coal quality. The cost of converting coal to gas in some of China's large cities is about 0.15 yuan/m^3, which is less than the selling price of \$0.20/m^3 in the United States. If coal were converted to gas close to mines, the gas would cost even less. The results are best if the hydrogenation catalysis method is used to refine the coal into oil, and each ton of coal can be refined into 0.4 to 0.5 tons of oil. Oil and gas can be obtained simultaneously using the low temperature dry

distillation method, and about half can provide semi-coke. Semi-coke is a very porous, easily burned smokeless fuel, and it also can be mixed with coke or used to make gas.

China's predicted resource reserves of slightly metamorphized coal suitable for refining into oil or gas exceed 1 trillion tons, with proven reserves of about 400 billion tons, located mainly in northwest and far northern China. The Ministry of Geology and Mineral Resources and the Ministry of Coal Industry have proven 200 billion tons of oil-rich coal at the border between northern Shaanxi and Nei Monggol.[6] The coal seams are stable, easily extractable, and have an ash content of less than 10 percent, an oil content of about 10 percent, and about 35 percent volatile components. The coal has a high caloric power as well as low sulfur and phosphorous contents. The pit-mouth selling price of the coal is only 2 to 4 yuan per ton. This coal field contains about 20 billion tons of oil and about 60 trillion m^3 of high caloric value gas. If they were refined out, they could play an enormous role in developing the national economy. China's oil refining specialists and coal chemistry experts all feel that processing of this type of coal is entirely possible, but that large investments would be required at the beginning to build the oil and gas refineries and the pipelines for shipping them out. If 500 million tons of coal were produced annually, it would be hard to ship it out by railway. The area has a water shortage and cannot build a great deal of industry to use this coal locally. If these 500 million tons of coal were manufactured into oil and gas, however, they could provide 40 million tons of oil and about 100 billion m^3 of (high caloric value) gas (equivalent to 100 million tons of oil). The two together equal 140 million tons of oil (more than present annual crude oil output) with a value of 21 billion yuan, while the figure for the 500 million tons of coal sold locally at the pit-mouth coal price would be only 1 to 2 billion yuan. The semi-coke remaining after refining the oil and gas also could be manufactured into low caloric value gas and shipped out for chemical industry and civilian use.

The thermal efficiency of direct combustion of coal is less than 20 percent, while the thermal efficiency of oil and gas can be as high as 40 to 50 percent. As a result, the conversion of coal into oil and gas can result in increased thermal efficiency, which is the same as increasing coal output. The results are especially good for civilian uses. Construction of a coal gasification plant in a city of 1 million people would require over 100 million yuan in investments.[7] Because it would conserve about one-half the coal, reduce coal and coal ash transportation, eliminate environmental pollution and also would permit recovery of associated elements in the coal, the coast

could be recovered rather quickly. Construction of a coal gasification plant in a coal producing area is even more economically sound.

Pipeline transportation of gas is much more convenient than railroad shipment of coal. The Soviet Union had completed more than 143,000 km of primary gas transmission pipelines by 1985 that run to every large city and factory. Some 90 percent of their iron and steel and 60 percent of their cement are refined with gas.

In regions with inadequate water, construction of coal gasification plants is even more appropriate. Gasification of one ton of coal requires about one ton of water. More water is needed, however, for a coal-water mixture, and the coal must be crushed into powder after it is washed, which increases costs. When using coal to generate electricity, each ton of coal burned consumes about 10 tons of water. Northern China has abundant coal and little water, so there are even greater advantages to gasification.

Second, adapt to local conditions for comprehensive utilization of low caloric value energy resource minerals.

In the structure of energy resource consumption in the Soviet Union in 1984, other energy resources accounted for 2.3 percent and exceeded the total for hydropower and nuclear power (1.8 percent). Other energy resources include oil shale, lumber, geothermal energy, peat and so on. The main one, however, is oil shale. A large scale thermal power station was built to burn the oil shale (the single unit generating capacity is 200,000 kW), and a small portion of the rich ore still is refined into oil and used to manufacture chemical industry products. The ash and slag are used as a building material and soil reforming agent. The Soviet Union has more energy resources than China but still is concerned with utilizing low caloric value minerals, which is something that we can learn from. China's oil shale industry has a foundation, but it never has received adequate attention. West Germany uses lignite with a caloric power of only 780 kilocalories/kg as a fuel for generating electricity. Greece uses lignite with a caloric power of 950 kilocalories/kg as a fuel for power generation to guarantee 70 to 80 percent of the nation's electric power. Oil shale in south China generally has a caloric power of more than 1,500 kilocalories/kg and the bone coal also has a caloric power in excess of 1,000 kilocalories/kg. The results of developing these minerals for power generation according to local conditions and using the ash and slag as a construction material, for building roads, and so on are not inferior to those of coal, and they conserve superior quality fuels and reduce the pressure on transportation.

V. Suggestions for Energy Resource Exploration

First, development of coal in China requires fewer investments than natural gas and petroleum despite their resource abundance. Consideration should be given to full use of coal to produce and substitute for some of the natural gas and petroleum. Coal production in Shanxi, Shaanxi, and Nei Monggol is determined by transportation and they cannot increase output substantially. Neither can several hundred billion tons of low grade reserves make it possible to increase the degree of exploration. For these reasons, on the basis of gratifying achievements in coal field geological work during the Sixth 5-Year Plan, we should continue to expand the search for coal in east China in regions with a coal shortage and the conditions for coal formation and locate even more accurate reserves to alleviate the energy resource shortage in east China to the greatest possible extent. Coking coal and the coal used in the chemical industry in east China should involve protective development. At the same time, development of economic construction in central and western China should be accompanied by advanced preparation of the required resources. It is particularly important that coal field surveys be reinforced in western Shanxi, northern Shaanxi and southern Nei Monggol to formulate comprehensive plans for large-scale extraction. Moreover, the water sources, construction materials and geological data on subsidiary minerals required for coal field development also be prepared.

Second, calculate gas reserves in the coal and include them in mineral balance charts. To increase reserves of natural gas (including coal-formed gas), besides hunting for conventional gas pools as quickly as possible, attention also should be given to non-conventional gas pools. About one-half of China's unified distribution coal mines contain high gas ores. Most of them are located in east and central China. According to forecasts made by relevant departments, China's coal mines contain about 15 to 18 trillion m^3 of gas. If one-tenth were used effectively, it would be equivalent to an increase in coal output of 3 to 4 billion tons. Some coal mines, like Fushun, Yangquan, Nantong, and others, altogether could extract 100 million m^3 of gas (equivalent to 200,000 to 300,000 tons of coal) that could be used at the mines themselves to convert a disadvantage into an advantage. Calculations of gas reserves would not require a great deal of additional work and would simply require a concern for comprehensiveness and accurate data during exploration for coal as well as analysis and organization to facilitate calculation of reserves. During the coal extraction process, it should be included among tasks for development and utilization. I suggest that in the future, calculations of gas reserves should be made during prospecting in high gas mines and reported to the Reserves Commission for approval.

Third, in regions with inadequate energy resources, and particularly in the provinces of east and central China south of the Chang Jiang, low caloric value minerals should be surveyed in accordance with local conditions to promote development and utilization. The region is somewhat rich in oil shale, lignite, bone coal, and peat. Substantial benefits could be created by local utilization of these minerals. At present, because the prices set for energy resources are so low as to make utilization of these minerals difficult, I am confident that as reforms in economic systems proceed, proper pricing arrangements will make it possible for these minerals to play a role. We should begin studying them early to promote development of the national economy.

FOOTNOTES

1. The discussion in this article does not include uranium ore resources.

2. 1986 NIAN ZHONGGUO MEITAN GONGYE NIANJIAN (GONGKAI CHUBAN) [1986 China Coal Industry Yearbook (Public Edition)]

3. In Table 1, data for China are taken from the 1986 ZHONGGUO MEITAN GONGYE NIANJIAN (GONGKAI CHUBAN). The other information is based on data from the State Planning Commission.

4. ZHONGGUO RIBAO [China Daily], 1987.

5. 1983 NIAN ZHONGGUO MEITAN GONGYE NIANJIAN (GONGKAI CHUBAN) [1983 China Coal Industry Yearbook (Public Edition)].

6. According to data from ZHONGGUO RIBAO, 17 June 1987, ZHONGGUO DIZHI BAO [China Geology Report], and JINGJI RIBAO [Economic Daily].

7. ZHONGGUO RIBAO, 13 June 1987.

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MINISTRY PROJECTS GROWTH OF 10 PERCENT IN 1988

40130044 Beijing XINHUA Domestic Service in Chinese 1250 GMT 14 Jan 88

[Article by reporter Wu Shishen]

[Text] Beijing, 14 Jan (XINHUA)--According to the Ministry of Water Resources and Electric Power, China's power generating capacity will continue to grow at an annual rate of 10 percent in 1988. This year, the country will strive to put into operation generators with a combined capacity of 9 million kW. This shows that since 1985, when China put into operation more than 5 million kW, the nation's electric power construction entered a new phase year after year.

To redress the acute electricity shortage, the state has made the electric power industry one of its top priorities in capital construction. To ensure balanced development and success, a "rolling" plan was adopted for electric power construction: the state plans to put into operation generators totaling 10 million kW from 1987 to the first half of 1988 and another 12 million kW from the second half of 1988 to 1989. The state has further strengthened overall coordination and organization in electric power construction. The State Council has held quarterly briefings on the situation in electric power construction. The State Planning Commission has convened monthly coordination meetings of the relevant departments to solve major problems in construction. Materials and supply departments, eager to meet construction needs, have done their best to help solve problems of equipment and material supplies so that construction can proceed smoothly.

Electric power construction reached a new peak in 1987. In addition to registering the highest installed capacity on record, the industry also set a new record in the installation of power transmission lines and construction of substations, overfulfilling by a big margin the planned targets. At an

electric power coordination meeting held today, a responsible person of the Water Resources and Electric Power Ministry said the ministry must work closely with equipment manufacturing, materials, banking, and transportation departments to overcome difficulties and achieve this year's goals in electric power construction.

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BRIEFS

1987 INSTALLED CAPACITY--China installed 9.204 million kilowatts in power-generating equipment in 1987, 35 percent more than in 1986; 8.13 million kilowatts in equipment were actually brought on stream, 20 percent more than in 1986. These figures represent all-time records. In order to meet its electric power demands, China is now moving toward large-scale equipment manufacture. China's first 300,000-kilowatt thermal unit (built with imported technology) went on stream last year at the Shiheng power plant in Shandong Province. China's first 600,600-kilowatt unit (also built using imported technology) is now being installed at the Pingxu power plant in Anhui Province. The 21 generators of the Gezhouba hydroelectric power station are all Chinese-made. [Excerpt] [Beijing RENMIN RIBAO in Chinese 30 Jan 88 p 2] 40130049/12223

EAST CHINA POWER CONSTRUCTION--Capital construction in the East China Power Grid is undergoing a surge. This year, some 3.6 billion yuan will be spent and 15 generating units will become operational (capacity: 1.81 million kilowatts). It has been reported that work has gotten under way on 52 generating units with a total capacity of 10.628 million kilowatts. These figures include those 15 units slated for completion this year. Power transmission projects this year are also more ambitious, with 560 kilometers of high-tension 500KV/lines to be completed along with 1.25 million KV in transformer installations. Projects include the Huainan-to-Shanghai and the Xuzhou-to-Shanghai 500KV a.c. lines and the Gezhouba-to-Shanghai d.c. transmission project. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 24 Feb 88 p 1] 40130053/12223

HUBEI POWER INDUSTRY--In 1987, Hubei Province installed generating sets with a combined capacity of 5.75 million kilowatts, an increase of 106.5 percent over 1980. Electricity produced during the year amounted to 25.988 billion kilowatt-hours, up to 100.7 percent over 1980. This was disclosed at a provincial meeting held on 20 January 1988. [Summary] [Wuhan Hubei Provincial Service in Mandarin 1000 GMT 21 Jan 88 HK] 40130044/12223

SHAANXI POWER SHORTAGE--This January Shaanxi Province's daily need for power approximated 46 million kWh, its daily power supply reached 37 million kWh, and its daily power shortage approximated to 9 million kWh. This kind of serious power shortage will continue until the end of this April. After May, with the increase in the volume of water coming from the Huang He, it is estimated that the province's power supply will improve to some extent. [Summary] [Xian Shaanxi Provincial Service in Mandarin 0500 GMT 25 Jan 88 HK] 40130044/12223

HEILONGJIANG 220KV LINE--Construction of a 220,000-volt high-tension power transmission and transformation line from Harbin to Jiamusi and Shuangyashan was completed and put into operation of 20 January. With a total length of 454.262 kilometers, it is the longest power transmission and transformation line in Heilongjiang Province. It will play an important role in alleviating the shortage of power supply in the eastern part of the province, Jiamusi City in particular, and in developing Sanjiang Plain. [Summary] [Harbin Heilongjiang Provincial service in Mandarin 1000 GMT 20 Jan 88 SK] 40130044/12223

BIG SHUIKOU PROJECT COULD BE FINISHED BY 1993

40130050 Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 20 Feb 88 p 1

[Excerpts] Work on the main structure of the Shuikou hydropower station in Fujian Province is now underway; the project is making use of loans from the World Bank and construction bids put out internationally.

The Shuikou hydropower station is located at midpoint of the main stream of the Min Jiang in Fujian Province and is the largest such project in eastern China. The total installed capacity will be 1.4 million kilowatts. A major item under the Seventh Five-Year Plan, the project will cost some 1.818 billion yuan. When completed, the station will supply up to 4.95 billion kilowatt-hours of electricity a year.

The Shuikou hydropower station is being constructed by a joint company consisting of China's Hualian Engineering Company and the Maeda Construction Company of Japan with a capitalization of 550 million yuan.

The main portion of the Shuikou hydropower project includes the dam, which is 768 meters long and 101 meters high, the power house, the switching station and substation, and the ship locks. The work on the main portion of the project is slated for completion in early 1993, at which time the No. 1 generator unit (installed capacity: 200,000 kilowatts) will formally go on stream.

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BRIEFS

GUANGZHOU PUMPED-STORAGE STATION--As a joint investment venture involving the Ministry of Water Resources and Electric Power, the Ministry of Nuclear Industry, and Guangdong Province, the Guangzhou Pumped-Storage Power Station has been approved by the State Council. The station will be located in Lutian Township, Conghua County, Guangdong Province, and will have an installed capacity of 1.2 million kilowatts in its first phase. The station is scheduled to be built and commissioned along with the Daya Bay nuclear power plant. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 20 Feb 88 p 1] 40130050/12223

MAJOR PROJECT WILL ALLEVIATE KUNMING'S CHRONIC POWER SHORTAGE

40130051 Kunming YUNNAN RIBAO in Chinese 25 Dec 87 p 1

[Summary] The Pupingcun power plant--a major energy construction project in Yunnan Province after the Manwan hydropower station--has brought its No. 1 generator on stream. The generator (installed capacity: 100,000 kilowatts) completed a 72-hour trial run (including 24 hours at peak load) without mishap and was formally put into operation on 21 December. The addition of this generator will provide more than 2 million kilowatt-hours of electricity to the provincial grid each day, helping to resolve some of the problems brought on by low water levels in reservoirs and peak power demands. Kunming is located right in the heart of the province's peak load zone and the area's thermal power plants previously had an installed capacity of only 100,000 kilowatts; much of the needed electricity had to be transmitted from plants located 200 kilometers away. The completion of this generator will make a considerable difference in the power supply picture in Kunming.

A major construction project of the Seventh Five-Year Plan, the Pupingcun power plant renovation plan calls for the installation of two 100MW high-temperature, high-pressure units for a total cost of 200 million yuan. The project is slated for completion in 1988. Since ground was broken on the project in November 1984, some 22 construction units and over 4000 personnel have participated in the work. The excavation work alone involved moving more than 700,000 cubic meters of earth and rock. In order to reduce urban pollution, dust scrubbers with an efficiency of 96 percent are being used, bringing the project up to the national environmental protection standards.

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BRIEFS

SHIDONGKOU NO. 1 UNIT ON STREAM--The No. 1 generator of the Shanghai Shidongkou power plant--a major project on the State's construction agenda--is running normally and as of 1430 hours on the 30th had produced 12.37 million kilowatt-hours of electricity. As each kilowatt-hour represents 6 yuan in industrial output value, this has already increased Shanghai's output value by 74 million yuan. From the beginning of construction to completion, the No. 1 unit took 2 and one-half years. Today, work on the entire plant is proceeding smoothly: the boiler framework for the No. 2 unit is in place and work on installing the steam turbine has begun. Civil construction work on units 3 and 4 has been accelerated. [Summary] [Shanghai JIEFANG RIBAO in Chinese 31 Dec 87 p 1] 40130045/12223

XUZHOU PLANT COMPLETED--Xuzhou, 24 Nov--The completion of the Xuzhou power plant, the third thermal facility in China with an installed capacity of more than 1 million kilowatts, was announced here today. Construction of the plant began in 1975. In the first and second building phases, four 125,000-kilowatt generating units were installed at a cost of 228 million yuan. the third phase of construction began in 1983 for an investment of 600 million yuan; four 200,000-kilowatt units were installed in this phase. [Text] [Shanghai JIEFANG RIBAO in Chinese 24 Nov 87 p 1] 40130045/12223

JILIN 200MW UNIT OPERATIONAL--Jilin, 26 Dec--The No. 1 200MW unit of the sixth phase expansion project of the Jilin thermal power plant is now operational. The sixth phase expansion project of Jilin is a major state construction item and is itself divided into two stages, the first of which has been completed some 6 months ahead of the original plan. With the bringing on stream of this new unit, the installed capacity of the plant has been boosted from 450,000 kilowatts to 650,000 kilowatts. [Text] [Changchun JILIN RIBAO in Chinese 27 Dec 87 p 1] 40130047/12223

DAWUKOU COMPLETED--Yinchuan, 19 Nov--The final unit of the Dawukou power complex--Ningxia's largest thermal electric power plant--will join the power network in the next few days. the

plant now has four 100,000-kilowatt units completely functional. After Dawukou's final generating unit becomes operational, the Ningxia electric power network's annual output can reach 2.4 billion kilowatt-hours, almost double that of 1985. Figures show that since the bringing on stream of the first three units, the total power output has been 2.35 billion kWh, 700 million kWh of which are provided to the Northwest power network. [Text] [Beijing RENMIN RIBAO in Chinese 20 Nov 87 p 1] 40130047/12223

GEOLOGICAL STRUCTURES, HYDROCARBON DISTRIBUTION IN BOHAI SEA REGION

40130074 Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 8, No 1, Mar 87 pp 45-54

[Article by Liu Xingli [0491 2502 0448] of the Bohai Petroleum Company: "Characteristics of the Layout of Geological Structures of the Distribution of Oil and Gas in the Bohai Sea Region"]

[Excerpts] [Abstract]

The Bohai Sea region is a part of the North China Basin which has undergone a developmental process from fault-subsidence to depression since the Cenozoic because of mantle uplifting. The structural configuration of the region is a structural pattern of three different strikes and four types of superimposed structural patterns of overlapped uplifts, overlapped depressions, uplifting then subsidence, and subsidence then uplifting. With the exception of the overlapped uplift regions, the other three categories all have excellent oil and gas prospects.

The Bohai Sea is a semi-occluded interior sea. Its geodesic structural position is a west Pacific Ocean continental margin structure region. It is a zone of intense tectonism and a part of the North China Petroliferous Basin. It is a Cenozoic fault-subsidence basin superimposed on the Sino-Korean Para Platform. It is bordered on the east by the Jiaoliao Uplift and on the west by the Shanxi Uplift. Its southern boundary is the Qinling Fold Belt and its northern boundary is the Yanshan Fold Belt. Crustal depth-sounding data indicate that the Moho is 29.4 km deep in the depression in central Bohai Sea and that it is a region of mantle uplift.

From the perspective of plate tectonics, the region is located between the Siberian, Pacific Ocean, and Indian Ocean Plates,

and they had inexorable effects on its structural development. During the Paleozoic, the Siberian Plate was subducted and compressed southward, which caused occlusion of the Tianshan-Xing' an ancient sea trench during the Hercynian Period. Contraction of the ancient Qilian-Qinling Sea also formed an aggregate southern margin[1] during the Caledonian Period. Subduction and compression to the south and north formed a series of nearly east-west oriented uplift zones and depression zones in the Bohai Sea region. This sort of structural configuration may have been sustained until the early Mesozoic. During the Mesozoic, the Pacific Ocean Plate was subducted in a NNW direction and the region was in a levo-rotatory shear stress field. This broke up the continental block and changed the east-west oriented structural deployment of earlier periods into a series of NE- or NNE-oriented structures. Since the Tertiary, following the occlusion of the Tethys Sea, the Indian Plate and the Eurasian Plate collided and were thrust and compressed northward. At the same time, subduction of the Pacific Ocean Plate under the eurasian Plate shifted from the former NNW to a WNW direction. This caused dextro-rotatory stress movement in the region and led to strong extension and thereby to the appearance of many contemporaneous fractures in the Bohai Sea and neighboring areas. This formed a regular pattern of alternating fault-subsidences and uplifts which assumed a northeast or nearly northeast configuration[2].

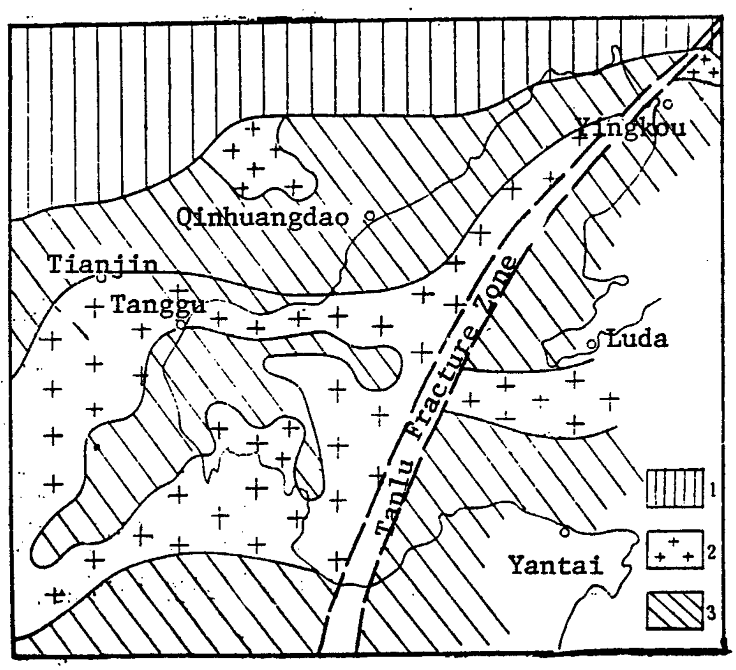
I. Historical Development of Geological Structures

1. Archeozoic and Lower Proterozoic

This was the stage of crystallization of the metamorphic basement of the Sino-Korean Para Platform. It includes three suites of strata containing the 2.5 billion year old Archeozoic and Early Proterozoic eras. The first suite is the Archeozoic group, represented by the Fuping, Qianxi, Anshan, and Taishan groups. The protolith was semi-clay rock, clastic rock, and basic volcanic rock formations with intense migmatization and granitization, and it extended up to 2.5 billion years ago[3]. The Taishan group was found below the Cambrian in two exploratory wells in southern Bohai Sea. Magnetic data indicate that the positive magnetic anamolies in central Bohai Sea west of the Tanlu Fracture Zone and the west Shandong region are indications of the Taishan Group. The second suite is the lower part of the Lower Proterozoic group, represented by the Wutai, Kuandian, and Jiaodong groups. The protolith is a suite of volcanic rock--sedimentary rock formations with varying degrees of metamorphization and migmatization. It lies unconformably on the Archeozoic and is 2.0 to 2.5 billion years old. Drilling in the western part of Liaodong [East Liaoning] Bay found granite-gneiss equivalent to the Kuandian group, and the magnetic field

also is a positive anomaly. There are, however, accretionary aggradation phenomena which form a periclinal portion with high magnetism. The third suite is the upper part of the Lower Proterozoic, represented by the Hutuo group, Liaohe group and Fenzishan group. It is a suite of lightly metamorphized sedimentary rock formations and is 1.7 to 2 billion years old. The magnetism is either a primarily negative anomaly or a zone of positive-negative anomaly variations (Figure 2).

Figure 2. Outline of Gravitational Field Zones in the Bohai Sea Region



Key:
1. Zone of alternating positive and negative gravitational anomalies
2. Zone of positive anomalies
3. Zone of negative anomalies

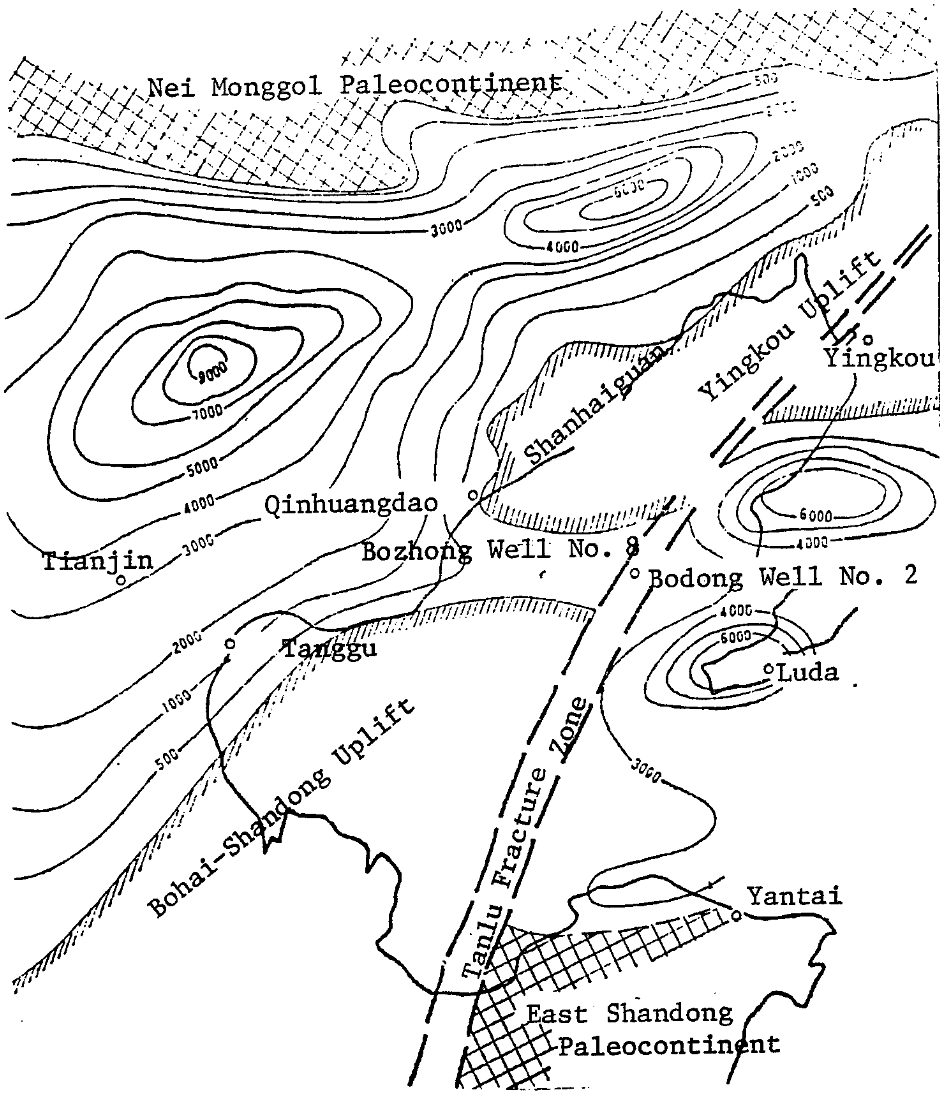
The three main periods of crustal activity from the Archeozoic to Early Proterozoic--the Fuping, Wutai, and Luliang--gradually formed a unified and solid platform foundation.

2. Middle and Late Proterozoic

After the Luliang Movement, a very long period of sustained marine intrusion occurred on the region's Archeozoic and Lower Proterozoic metamorphic basement. the Middle and Upper Proterozoic attained their maximum thickness of 9,500 m in Jixian Depression on the northwest side of the Bohai Sea (Figure 3). They formed a sedimentary cycle of clastic rock (Changcheng system)--carbonate rock (Jixian system)--clastic rock interbedded with carbonate rock (Qingbaikou system). Because it was restricted by the Bolu [Bohai-Shandong] Uplift, the sea basin contracted. With the exception of about 1,000 m of sediments encountered in northwest Bohai Sea, the Bozhong [Central Bohai Sea] Well No. 8 encountered only 20-odd meters of Longshan group glauconitic quartz sandstone at Shijiutuo Uplift south of Qinhuangdao Island. It is a Middle and Upper Proterozoic group sediment in Jixian Depression which overlaps the Shanhaiguan Uplift. The Middle Proterozoic did not develop in east Bohai Sea, while the Liaonan group, which is the equivalent of the Upper Proterozoic group, is quite developed east of the Tanlu Fracture Zone within the Bohai Sea. The sedimentation center is near Fuzhou and is more than 6,000 m thick. It also is reflected as a complete cycle of clastic rock, argillaceous rock--carbonate rock--argillaceous rock, and clastic rock. The middle and upper Liaonan [Southern Liaoning] group carbonate rock is concentrated mainly in the Fuzhou-Luda region. At sea, only 56 m of it (not drilled through) were found at Bozhong Uplift in the Tanlu Fracture Zone. By extrapolation, the distribution of the Liaonan group would be limited to the area east of the Tanlu Fracture Zone. A large amount of exploratory drilling on land also has shown that the Liaonan group in Taizihe Depression does not extend beyond the western fracture in the Tanlu Fracture Zone.

(Figure 3 on following page)

Figure 3. Map of Middle and Upper Proterozoic Thicknesses in the Bohai Sea Region



Much tectonic activity took place during the Middle and Late Proterozoic, mostly uplifting, with no obvious folding deformation. It is apparent from a map of the thickness of the Middle and Upper Proterozoic that the paleostructures ran mainly in an east-west direction and secondarily in a northeast direction.

3. Paleozoic

At the end of the Proterozoic, the Sino-Korean Para Platform was uplifted as a whole. It received typical shallow sea platform sediments from the Early Cambrian to the Middle Ordovician.

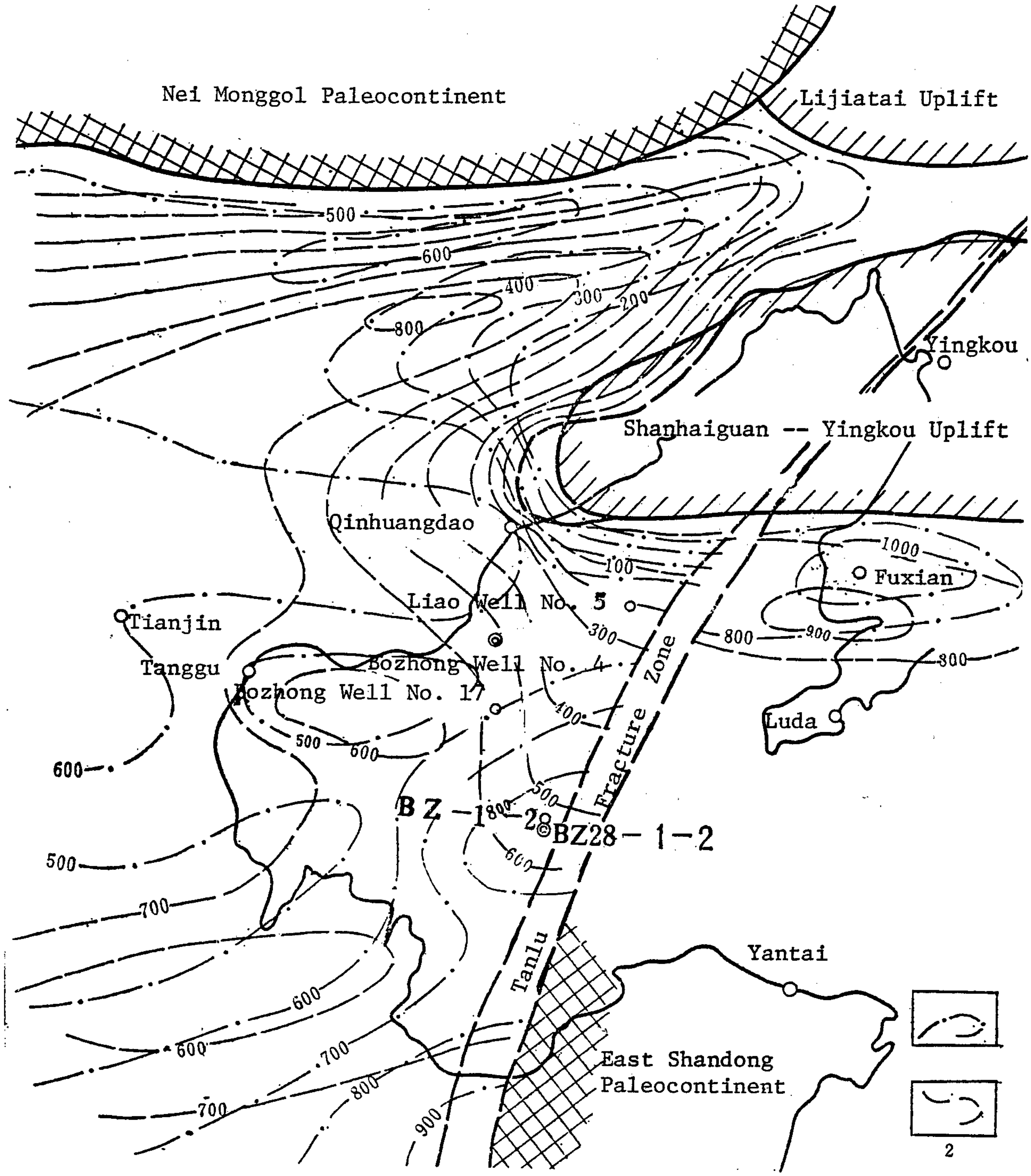
They are distributed throughout the Bohai Sea region with the exception of the higher portions of the Shanhaiguan-Yingkou Uplift, which did not receive sediments. The Lower Cambrian is mainly clastic rock and clay rock interbedded with carbonate rock, while the Middle Cambrian to Middle Ordovician are mainly carbonate rock. The Cambrian and Ordovician are generally 1,200 to 1,400 m thick in the Bohai Sea.

From the end of the Middle Ordovician to the Early Carboniferous, the platform was uplifted and underwent a a 130 million year sedimentary hiatus. The enormously thick Ordovician limestone underwent a long karst period and gradually was leveled. The entire region subsided again throughout the Middle Carboniferous and formed land-sea interchange facies coal-bearing formations. It received coal-bearing bog sediments during the Early Permian and plain river facies sediments during the Late Permian. There was no obvious hiatus between the Carboniferous and Permian. At present, very few exploratory wells at sea have encountered the Carboniferous or Permian systems. The variations in thickness are not entirely clear but they are estimated at about 1,000 m.

It is apparent from the map of Cambrian and Ordovician thicknesses (Figure 4) that there is a major difference between the tectonic activity during the Paleozoic and activity during the Middle and Late Protozeroic in that uplifting and subsidence was replaced by stable uplifting as a whole. They did, however, retain the characteristic mainly east-west oriented structural configuration.

(Figure 4 on following page)

Figure 4. Outline of Cambrian and Ordovician System Thicknesses in the Bohai Sea Region



Key:

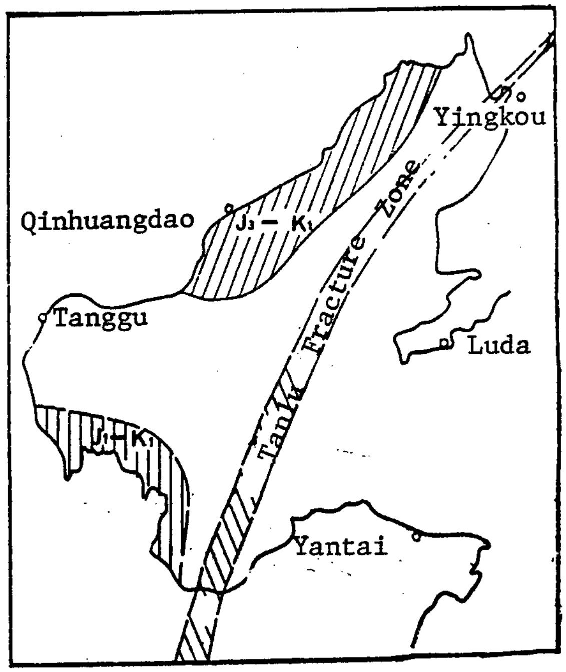
1. Cambrian System thickness contours (m)
2. Ordovician System thickness contours (m)

4. Mesozoic

The Indosinian Period saw changes in structural development of the Sino-Korea Para Platform. Intense crustal movements formed many new structures. Previously, uplifting activity had dominated and the structural configuration was characterized by an east-west strike. During the Indosinian activity, it changed to a structural configuration characterized by northeast-oriented uplifting, folding and faulting during the Yanshan Period. The Triassic is absent over the entire sea area and most of the region lacks the Middle and Lower Jurassic systems. Analysis of existing data indicates three rather large-fault-subsidence zones in the Bohai Sea region which received very thick Jurassic and Cretaceous volcanic clastic rock sediments (Figure 5). The first zone runs from the western part of Liaodong Bay to the Shijiutuo area. It is located southeast of the Shanhaiguan Uplift along the downthrown side of a large fracture. It accumulated more than 1,000 m of Upper Jurassic--Lower Cretaceous volcanic clastic rock and has a maximum thickness exceeding 4,000 m. Exploratory drilling already has revealed the upper 1,000 m of strata. The second zone runs from the southern end of the Tanlu Fracture Zone in the Bohai Sea and Laizhou Bay to the Bodong [East Bohai] Low Uplift Zone. It is mainly Lower Cretaceous volcanic clastic rock over 2,000 m thick. A thickness of 1,536 m has been drilled (not drilled through). The third zone lies along the southwest coast. It runs in a roughly northwest direction and the sediments are mainly Jurassic and Cretaceous clastic rock interbedded with volcanic rock. It also is more than 2,000 m thick and a thickness of 819 m has been drilled (not drilled through).

(Figure 5 on following page)

Figure 5. Map of Primary Distribution of the Mesozoic System in the Bohai Sea (sediment thickness > 1,000 m)



5. Cenozoic

After the Yanshan Movement, tectonism in the Bohai Sea region entered a new period of development. The Crust changed from regional uplifting to regional subsidence and underwent a process of development from fault-subsidence to subsidence. the Eogene sediments and structures have the properties of a continental rift valley. The strike of Cenozoic structures was controlled by Yanshan Period northeast structures. They also were affected by the Indosinian Period east-west structures.

At the end of the Mesozoic and beginning of the Cenozoic, mantle uplifting in the Bohai Sea caused regional arched uplifting of the crust. The Upper Cretaceous and Paleocene are generally absent, and the center of uplifting was in the middle of the Bohai Sea.

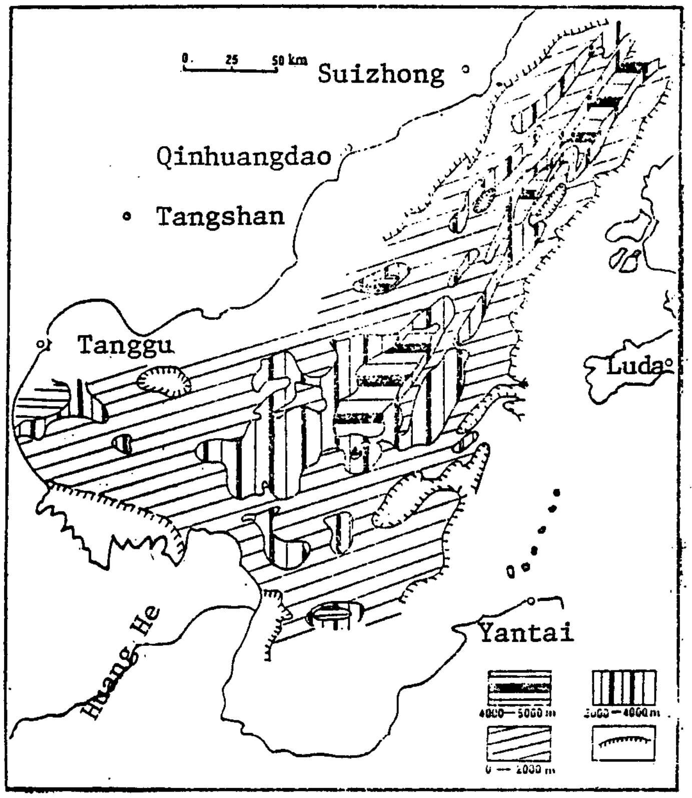
The Eocene was a stage of early fracturing and subsidence. The strong extensional stresses caused by mantle uplifting led to extensional fracturing in the crust along the mantle uplift zones centered on Bozhong where the crust was thinnest and structures the weakest. Several large fracture-subsidences started forming and developed to the greatest extent in the southern part of the modern Jiyang and Huanghua Depressions,

in the northwestern part of the Lower Liaohe Depression, and in central Liaodong Bay. Basalt also erupted during the Early Eocene and a suite of red beds of terrigeneous clastics containing gaoyan [5221 1484] assumed to be a kind of evaporite and carbonate rock also filled in quickly. It also is possible that there may have been a transitory marine intrusion. It certainly has the lithologic and geodesic combinational characteristics of an early continental rift valley. At the end of the Eocene, the crust arched further upward, tilting and twisting the formerly almost-level fault blocks. The tops of the upward-tilting sides were eroded and gradually formed unconformable contacts with the Oligocene.

The Oligocene was a stage of transition from intense rift valley fracture-subsidence to rift valley extinction. Initially, mantle uplifting also intensified. It was manifested as sustained intense horizontal crustal extension with deep vertical subsidence and associated submarine basalt eruptions. A suite of alternating flysch formations and sandy mudstone often formed in the centers of the depressions. The sloping sides of the depressions have deltas, fault cliff fans and other wedge-shaped sedimentary bodies. The Middle Oligocene saw the start of weakened tilted fault-block movement. A marine progression sedimentation sequence developed throughout, and there also was a normal cycle sequence from coarse to fine and from primarily clastic rock to mainly argillaceous and limy rock. The Late Oligocene saw a reverse cycle sequence from fine to coarse. It was the period of greatest deltaic development and created widespread overlapping sediments. There is a rather obvious segmentation in Lower Tertiary accumulations and major variations in thickness in each of the depressions. They are characterized by multiple sources of materials and multiple sedimentation centers. The maximum thickness exceeds 5,000 m (Figure 6).

(Figure 6 on following page)

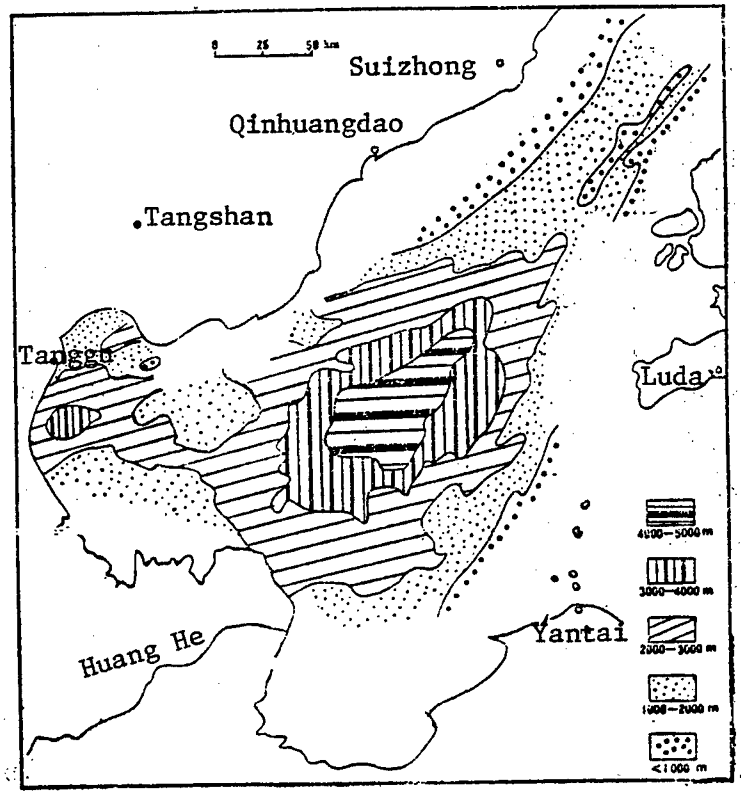
Figure 6. Map of Lower Tertiary Thickness in the Bohai Sea



At the end of the Oligocene, changes also took place in the structural properties of the region. The eventual collision between the Indian and Eurasian Plates changed the original subductional relationship between the Pacific Ocean and Asian Plates. Uplifting of west China on an even greater scale caused northern China as a whole to begin to subside, and central Cohai Sea was better able to become a sedimentation center from the Late Ologocene to the Neogene. The Upper Tertiary is a suite of mainly river facies molasse formations more than 4,000 m thick. Moreover, they lie unconformably on top of the Lower Tertiary and other older strata. The Neogene basically ended the regional extensional movements and brought to a premature end the history of a continental rift valley that failed to develop to maturity. At this time, north China became a basically unified Upper Tertiary subsidence basin centered on

(Figure 7 on following page)

Figure 7. Map of Upper Tertiary to Quaternary System Thicknesses in the Bohai Sea



II. Structural Configurations and Their Relationship to the Distribution of Oil and Gas

The structural configuration of the Bohai Sea region is a pattern of three different strikes and four types of overlapped uplifts and depressions. The three strikes are an east-west or nearly east-west strike, a northeast or NNE strike and a northwest strike. As explained previously, the east-west strike developed earliest. It began in the Proterozoic and continued to the Early Mesozoic. The northeast strike developed later, mainly during the Mesozoic and Cenozoic. Most of the northwest strikes are associated components of the first two and their distribution is rather limited.

The sequence of east-west oriented structures moving north to south is: Nei Monggol Axis--Lijiatai Uplift, Chengde Depression--Taizihe Depression, Shanhaiguan Uplift--Yingkou Uplift, Jixian Depression--Fuzhou Depression, Shaleitian Uplift--Loatiehsan Uplift, Qinan Depression--Yellow River Mouth Depression, Wudi Uplift--Kendong Uplift, and Huimin Depression--Laizhou Bay Depression.

Moving north to south, the east-west oriented structures have a tendency to weaken, become younger and display lesser degrees of uplifting and subsidence.

The sequence of the northeast-oriented structures moving west to east is: Cangxian Uplift, Huanghua Depression, Chengning Uplift, Liaohe-Bozhong-Jiyang Depression, and Jiaoliao Uplift.

The superimposition of two groups of alternating uplift and subsidence structures above and below from different periods and with different strikes led to the appearance of new combinational patterns. Preliminary analysis indicates four types: 1) Overlapped uplifts, 2) Overlapped subsidences, 3) Uplifting then subsidence, and 4) Subsidence then uplifting. Because they were affected by a long period of complex geological structural activity, regularity in geometric configuration of such relationships of superimposition was impossible. Careful study, however, may permit discovery of regularities in their relative planar positions and vertical stacking relationships. Moreover, there are extremely close intrinsic relationships between different types of structural superimposition and the distribution of oil and gas.

1. Overlapped uplift regions

These underwent long-term relative uplifting in their geological development process and have the thinnest sedimentary rock. Because the uplifting occurred early, the Middle and Upper Proterozoic, the Paleozoic and the Middle and Lower Jurassic generally are absent, although certain areas may have thin Paleozoic overlaps. Later periods also involved uplifting, and the Jurassic, Cretaceous and Lower Tertiary basically are absent. Moreover, this once again eroded the Lower Paleozoic sediments, which were very thin in the beginning, and formed direct contacts between Precambrian metamorphic rock or granite and the Upper Tertiary over a large area. In some cases, Late Oligocene strata overlap the peripheral slopes of the uplifts.

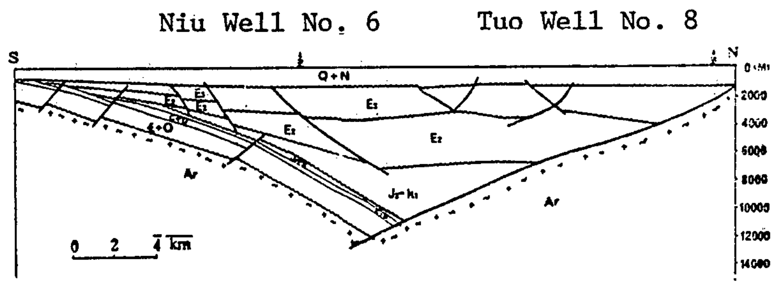
The overlapped uplift regions usually are rather distant from oil-generating depression and their entrapment conditions also are rather poor, mainly involving buried hill draped structures. In addition, because the Upper Tertiary sediments are rather coarse, capping strata conditions naturally are not very ideal. The main prospecting target is oil generated in new rock and reservoired in old rock in buried hill oil pools and Upper Tertiary secondary oil pools formed of metamorphic rock or granite. An example is the Upper Tertiary secondary oil pool encountered at the Haizhong [Midsea] No. 1, Haizhong No. 3, and other wells on the Shaleitian Uplift. These oil pools are

characterized by heavy oil quality, low output, shallow burial and so on. In economic terms, overlapped uplift regions are not primary targets of offshore exploration at present.

2. Overlapped depression regions

These areas underwent long periods of relative subsidence. The strata and sediments are relatively complete, and the Paleozoic, Mesozoic and Cenozoic all are fairly developed. The Middle and Upper Proterozoic also can be found in some areas (Figure 9).

Figure 9. Section of an Overlapped Depression Region (Dongying Depression)



Overlapped depression regions include the Qinan, Dongying, Laizhou Bay, Yellow River Mouth, Bozhong (northern part) and other depressions and the Lower Liaohe Depression on land. Because all strata suites are fairly developed in overlapped depression regions, it may be possible to find Lower Tertiary primary oil and gas pools, ancient buried hill oil and gas pools on the higher parts of the relative uplifts, and secondary (with some primary) oil and gas pools of oil generated in the Lower Tertiary and reservoired in the Upper Tertiary. Strata systems have been explored to the greatest extent here, all types of traps have developed, and there is an excellent matchup of generation, reservoiring and capping conditions. These are the areas of the North China Petroliferous Basin where the majority of all types of large and medium-sized oil and gas pools have been discovered. Examples include the Dongying Depression and Lower Liaohe Depression on land, and the Yellow River Mouth Depression at sea, where many oil and gas pools and high output oil- and gas-bearing structures have been discovered. These regions will continue to be the focus of future exploration.

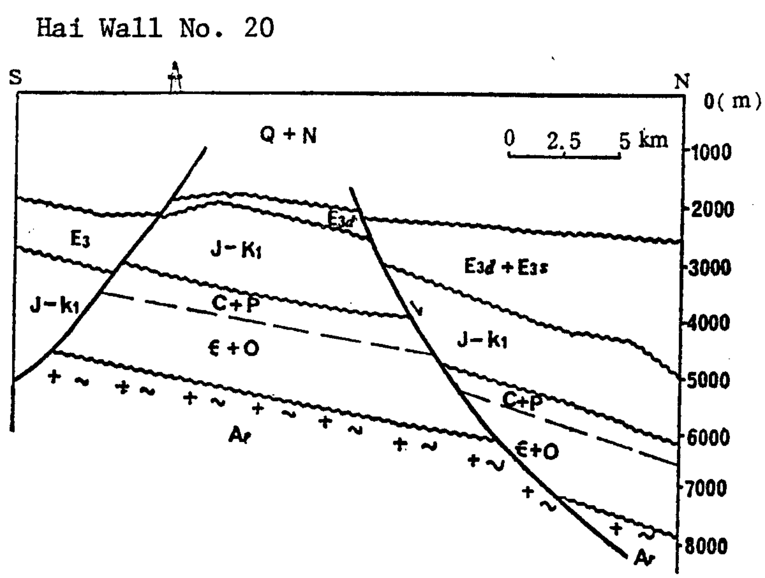
3. Early uplift late subsidence regions

Examples of these regions include the central part of the Qikou Depression, the southern part of the Bozhong Depression (the Bozhong gravity High), and the central and northern parts of Liaodong Bay. The Middle and Upper Proterozoic are absent in these regions, and the Paleozoic and Lower Mesozoic also are absent or accumulated only very thinly. The Tertiary, however, is extremely developed, and Precambrian metamorphic rock or granite are in contact with the Tertiary in both uplifts and subsidences. These regions apparently do not contain buried hills composed of carbonate rock, but instead are formed mainly of Precambrian metamorphic rock and granite or Mesozoic volcanic clastic rock. The oil generation conditions in these regions and the oil formation conditions within the Tertiary are similar to those in the overlapped depression regions, in that is realistic to look for ancient buried hill oil and gas pools in metamorphic rock or granite. Exploratory drilling over the past few years has confirmed that high output oil and gas pools or oil-bearing structures have been discovered in metamorphic rock and granite, both on land and at sea. This is a prospecting target with substantial petroliferous potential which deserves attention.

4. Early subsidence late uplift regions

These regions include the Chengzikou, Chengbei (Figure 10), Shijiutuo, Bonan-Miaoxi and other uplifts and Fuzhou Depression.

Figure 10. An Early Subsidence Late Uplift Region (Chengbei Low Uplift)



Early on, the Paleozoic and Mesozoic were fairly developed in the early subsidences. Some regions have very thick Proterozoic systems (Fuzhou Depression), and excellent carbonate rock reservoir bodies often formed in the ancient buried hills. If they were uplifted higher in later periods, however, the strata may have been severely eroded. Examples include the top portions of the Chengzikou, Shijiutuo, Bonan-Miaoxi and other uplifts, where a direct contact with Tertiary and Precambrian metamorphic rock is formed. During these periods, they were similar to the situation in the "overlapped uplift regions." The relatively lower parts, however, retained some of the Paleozoic, Mesozoic and even the Middle and Upper Proterozoic systems, and they also have a certain thickness of overlapping Lower Tertiary above them which forms excellent capping strata. The uplifting process often was associated with contemporaneous fault facies, and the fractures or unconformities became channels for the migration of oil and gas. It is apparent from this that in terms of the lithologic combinations concealed within buried hills, capping strata conditions, oil and gas migration channels, depth of burial of prospecting target strata, and other conditions in the early subsidence late uplift regions, all of them are the best regions to explore for buried hill oil and gas pools, and the many such oil and gas pools found on land and at sea provide strong confirmation that these will be important regions for continued exploration in the future.

The above discussion concerning the structural superimposition relationships of uplift and subsidence was limited to higher-order structural components. Actually, under identical stress field influences, lower order structures and even repeated oil and gas accumulation structure zones also would have similar structural distribution characteristics and even more definite superimpositional relationships, and moreover, there would be an even closer intrinsic relationship to the distribution of oil and gas.

This article depended mainly on the results of research by the Bohai Petroleum Company over the years. Wang Jincheng [3769 6930 1004] of the Ministry of Petroleum Industry's Marine Petroleum Prospecting Bureau Research Academy's Cartography Office and other comrades prepared the illustrations, for which I would like to express my gratitude.

FOOTNOTES

1. Zhang Kai [1728 1956] et al., SHIYOU XUEBAO [Petroleum Journal], Vol 1, No 1, 1980.

2. Li Desheng [2621 1795 3932], SHIYOU XUEBAO, Vol 1, No 1, 1980.

3. Wang Shangwen [3769 1424 2429] et al., ZHONGGUO SHIYOU DIZHIXUE [China Petroleum Geology], Shiyou Gongye Chubanshe, 1983.

12539/12223

FOREIGN INTERESTS SPEED DEVELOPMENT OF XINJIANG FIELDS

40130042 Hong Kong LIAOWANG [OUTLOOK WEEKLY] in Chinese No 2, 11 Jan 88, pp 10-11

[Article by Xin Buwen [6580 0592 2429]: "International Collaboration Accelerates Exploration of Xinjiang Fields"]

[Excerpts] On 4 August 1987, in the assessment meeting held jointly by Xinjiang Petroleum Management Bureau and Geophysics Corporation of France in Urumqi, Huang Hongze [7806 3136 3419], representing the Chinese side, said that satisfactory results have been obtained in the last 2 to 3 years with international collaboration. The progress made in seismic prospecting in Junggar Basin in one year is equivalent to 5 years of work in the past.

Oil and gas have been found in the three major basins in Xinjiang--Junggar, Turpan, and Tarim--as well as in 20 or so medium and small basins in recent years by various international prospecting activities. It is estimated that sedimentary rock covers 915,000 square kilometers. In addition to finding new fields in the Junggar Basin oil fields have been found in the western Tarim Basin at Yixikelike, Kekeya south of the highway between Luntai Kuche and Wuge, and north of the Tarim River. In addition to the Karamay fields, 12 fields were found in places such as Hongshanzui, Baikuoquan, Fengcheng, Wuerle, Xiazijie, and Qigu.

Sino-French Joint Effort to Survey the Junggar Basin

Zhang Songhan [1728 2646 5060], director of the geological survey section of the Xingjiang Petroleum Bureau, indicated that the period in which the fastest progress and most significant results were obtained in prospecting for oil was in the first 9 years after China opened its door to the outside. In 1979, for the first time French technology and equipment such as digital seismic exploration machine and controllable seismic focus were used in Xinjiang. This ended the practice of manual drilling

and setting off explosion for exploration in the Gobi Desert. In 1980, in cooperation with the French Geophysics Corporation, we conducted a multiple coverage seismic survey in the Junggar Basin. A rough survey of the entire basin, including desert areas, was completed in 3 years. Promising areas were further explored and specific local areas were looked at in detail. This study gives us a better understanding of the geological structure of the Junggar Basin and its northwestern rim. In February 1985, the Xinjiang Petroleum Management Bureau signed a 2-year contract with the French Geophysics Corporation to continue the work into a second phase. On 2 March, Chinese and French personnel entered the desert area in the northeast part of the Junggar Basin for exploration.

The Junggar Basin covers an area of 130,000 square kilometers, most of it in the Gobi Desert. Before 1979, Chinese survey teams relied on camels to enter the desert. The French-Chinese teams were equipped with cross-country vehicles with low-pressure tires, and lived in tents in the field. A drilling vehicle was available. With their modern equipment, the desert is no longer an obstacle. The speed of the survey was significantly accelerated. From 1980 to April 1987, we completed 16,458 kilometers of seismic cross-section and identified 35 oil-bearing structures in the basin. The team led the country in progress and achievement in the petroleum industry. More than 95 percent of the data provided were classified high quality as specified by the Ministry of Petroleum Industry.

Zhang Songhan said that the oil reserve in the Karamay field was doubled based on the survey data provided by the French-Chinese team. They also found 200 million tons of heavy oil. In addition, they discovered the Kalameili and Wucaiwan fields in the eastern part of the Junggar Basin.

The manager of the French Geophysics Corporation told reporters in Urumqi that prospects of finding oil in the Junggar Basin are good. In the last two phases of work, both sides cooperated in a friendly manner and obtained satisfactory results. Recently, the work has been continued into a third phase beginning in October.

American-Chinese Cooperation in the Shahai Field.

The Taklimakan Desert in the Tarim Basin covers 320,000 square kilometers.

Associate Director Xie Hong [6200 1347] of Xinjiang Petroleum Bureau told reporters that China began to work with the Global Resources Corporation in the United States in 1983 to conduct

gravitational and seismic surveys in the Taklimakan Desert for 3 years. This is the first large-scale, systematic oil exploration effort in the area.

To ensure the safety of the survey personnel, the base has two helicopters on standby at all times for rescue missions. A radio network was also set up for all areas covered by the survey. The network covers 160,000 square kilometers of area in Xinjiang and can communicate with the command posts of all survey teams. The seismic team successfully completed a series of surveys with the help of helicopters and large wide track, low pressure tire cross-country vehicles without suffering a single casualty. No equipment was buried by the sand either.

A great deal of geophysical data has been collected over the three years. It is known that the Tarim Basin has three major bulges and four major dips. There are 136 local structures and 53 potentially attractive structures. To date, there are two gas fields; 13 structures showed the presence of natural gas.

An analysis of the data shows that there are 18.45 billion tons of crude oil resources in the Tarim Basin. This is the most promising area for oil prospecting in inland China. To further determine oil resources, the Chinese government began a yearly appropriation of 300 million yuan in 1987 to conduct surveys in the basin's desert areas. Oil companies from more than 20 countries have visited the Southern Xinjiang Petroleum Exploration Command Center and talked about joint ventures. The Xinjiang Petroleum Bureau is willing to continue collaboration with foreign exploration firms.

Bringing in New Technology

Since 1979, the Xinjiang Petroleum Exploration Department has imported a number of modern analytical instruments from the United States, East Germany, Japan, West Germany, France, and Italy to strengthen petroleum geological research. Certain technology imported is state-of-the-art in the world. For example, we brought in digital logging machines and computers to serialize the logging work, digitize the instrumentation and automate the data interpretation process. As another example, the Karamay Field cooperated with the United States and drilled 38 test wells in the northwest part of the Junggar Basin; 12 state-of-the-art methods have been used in the project.

In order to solve the blowout problem with the No. 1 well in the Kekeya field located at the foot of the Kelakunlun Mountains in southern Tarim Basin, the Xinjiang Petroleum Bureau worked with the Parker Company in the United States to drill a slanted well 3,820 meters deep. The maximum angle is 19 degrees, 54 minutes. This is the first slanted well in the Tarim Basin.

Xinjiang Petroleum Drilling Corporation recently imported some coring tools from the United States which have significantly improved the drilling speed in the Carboniferous system.

12553/12223

BRIEFS

TAKLIMAKAN DEPOSITS--There is an "ocean" of oil beneath the great Taklimakan desert that exceeds previous estimates by more than 10 billion tons. This information has been released by the Geophysical Prospecting Bureau of the Ministry of Petroleum Industry. Rich oil and gas-bearing zones in the Tarim Basin cover an area of some 100,000 square kilometers. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 19 Feb 88 p 1] 40130052/12223

JILIN CRUDE PRODUCTION--The year 1987 was Jilin's second highest-yield year for crude oil production since the field went into operation 27 years ago. The output in 1987 was 2.864 million tons, up 20.9 percent from the previous year. Crude oil production grew from ninth to eighth in the nation, the absolute production ranked fourth in the nation, and the growth rate ranked top among the nation's nine major oil fields. [Summary] Changchun JILIN RIBAO in Chinese 10 Jan 88 p 1] 40130052/12223

CRASH EFFORT COULD PUT FBR'S ON STREAM BY 2015

40080008b Beijing WULI [PHYSICS] in Chinese Vol 16, No 8, Aug 87 pp 487-493, 460

[Article by Li Shounan [2621 1108 2809], Chinese Institute of Atomic Energy: "Fusion-Fission Hybrid Reactors--The Path of China's Development of Breeder Reactors"]

[Excerpts] In 1980 in my report at the meeting to establish the China Nuclear Society I proposed as a nuclear energy development strategy for China that in the second stage of China's nuclear energy development whether we could abandon the fast breeder reactor and take the path of the fusion-fission hybrid reactor. It was well received by the plasma Physics Institute of the Chinese Academy of sciences. Subsequently, a small group was established to conduct a study of the hybrid reactor and in 1985 proposed the HTHR physics concept design of China's first hybrid reactor[7]. In 1984, I systematically introduced the fusion-fission hybrid reactor at such locations as the Nuclear Industry Ministry's Fast Reactor Verification Meeting and the Southwest Physics Institute[8] and presented my proposal for dividing the development of fusion in China into the two stages: a hybrid reactor and a pure fusion reactor. It was unanimously supported by the leadership and science and technology personnel of the Southwest Physics Institute. In 1985 this institute completed a concept design of a more complete magnetic mirror hybrid reactor (CHD)[9]. In December 1985 China's first Hybrid Reactor Symposium was held at Leshan in Sichuan. Here, the strategic concept of a two-stage development of China's nuclear fusion was unanimously approved. Through efforts in a variety of areas, the fusion-fission hybrid reactor is now ranked with the fast reactor as a pre-research topic for China's Seventh Five-Year Plan to further certify the policy-making.

To explain the advantages of hybrid reactors, we will first make some comparisons of the fusion breeder reactor (hybrid reactor) and the fission breeder reactor (fast reactor).

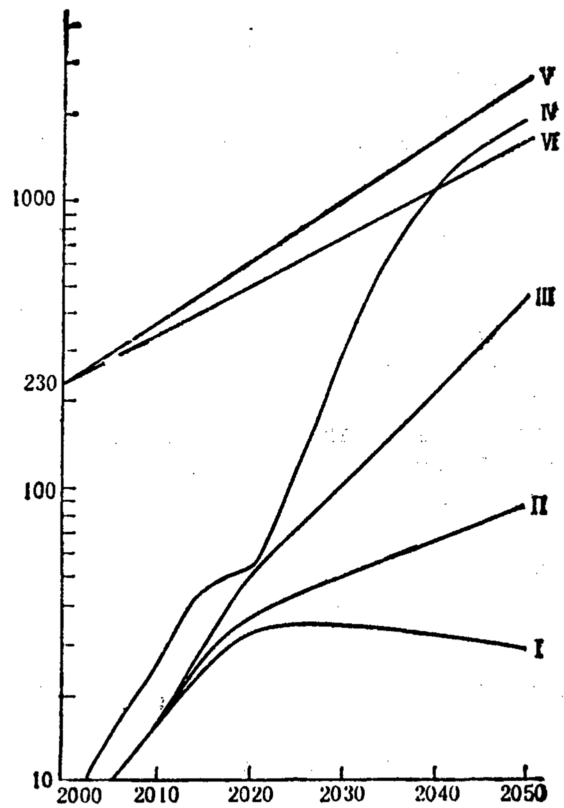
Hybrid Reactor Breeder Energy Is Much Greater Than Fast Reactors

We have mentioned that the pure breeder ratio of fast reactors is small, multiplication time is long (for example, the Super-Fenghuang-1 breeder ratio is 1.1 and multiplication time is 40 years), the nuclear fuel breeder capability is poor, and the support ratio is much smaller than that of the hybrid reactor.

Fast reactor power plant construction was inhibited by initial fueling with industrial plutonium, but the hybrid reactor does not have this problem. The Super-Fenghuang-1 fast reactor initial fueling required 8 t of industrial plutonium in the reactor with an annual output of 200kg of plutonium. After the oxide sodium cooled fast reactor was transformed, the best circumstances were estimated to be initial fuelling of 5 t and annual output of 250kg of plutonium. In the future, using carbide or metallic uranium fuel, the initial fueling can reach 3 t with annual output of 300kg of plutonium, but it will still be inhibited by the initial fueling with industrial plutonium.

China's rated electric power generating capacity by the year 2000 is estimated to reach 230GWe and if the average annual increase after the year 2000 is 4 percent, the gross rated capacity by the year 2050 will be about 1,635GWe. It is said that China's uranium reserves can only supply 15GWe pressurized-water reactors for 30 years. With U/Pu circulation it also can only be 21GWe. China's nuclear power plant construction is too late and too slow and extremely unfavorable for accumulating industrial plutonium growth fast reactors. If 15GWe in nuclear power is built before the year 2010, and another 10GWe added between the years 2011 and 2015, and another 105We added between the years 2011 and 2015, then the total will reach 25GWe by the year 2015. If fast reactors are introduced beginning in the year 2010 and all industrial plutonium produced by pressurized-water reactors and fast reactors is used to develop fast reactors, then the nuclear power rated capacity provided by pressurized-water reactors and fast reactors with different breeding capabilities together are illustrated by curves, I, II, and III in the figure. From the figure, it is clear that fast reactors cannot resolve China's energy problem in the 21st century.

(Figure on following page)



Nuclear power which can be provided by different breeder reactor systems

Curve I is fast reactor+LWR, initial fueling 6 t, annual output of plutonium is 150 kg;
Curve II is fast reactor+LWR, initial fueling 5 t, annual output of plutonium is 250 kg;
Curve III is fast reactor+LWR, initial fueling 3 t, annual output of plutonium is 300 kg;
Curve IV is hybrid reactor+LWR, year 2020 introduction of fission hybrid reactor (support ration 6),
Year 2050 introduction of controlled fission hybrid reactor (support ratio of 20);
Curves V and VI are China's needs for electric power increase (V is annual increase of 4 percent after the year 2000, VI is annual increase of 5 percent after the year 2000)

Hybrid reactor construction is not inhibited by accumulation of industrial plutonium, and as soon as the technology matures and economic resources permit, development can be accelerated. If we can concentrate our forces and work hard, hybrid fission reactors can go into operation in China in the year 2015, and it is possible that about the year 2020-2025 controlled fission hybrid reactors can go into use. Since the hybrid breeder reactor's capacity is powerful, soon after construction it can

supply fuel for pressurized-water reactors. The above-mentioned 25GWe nuclear power station fuel can be used for a total of 750 reactor-years. While the pressurized-water reactors will use low concentration natural uranium for the first 15-20 years, later they can use fuel supplied by hybrid reactors. Thus in the early period, more pressurized-water reactors can be built. If each year we begin to construct one fast fission hybrid reactor-pressurized-water reactor system with a support ratio of 6 and after the year 2025 add two more per year; then after the year 2025 we construct one controlled fission hybrid reactor co-generation system (support ratio of 20) and after the year 2030 add two per year, then according to this plan the nuclear power electricity rated capacity of the hybrid reactor-pressurized-water reactor co-generation system will be as illustrated by curve VI in the figure. This shows that the hybrid reactor-pressurized-water reactor co-generation system will provide a possible road for resolving the problem of China's energy shortage in the 21st century.

The fast reactor (construction cost ratio for LWR is higher by 30 percent, multiplication time is 15 years)+LWR(one pass) co-generation system; $D+H_1$, $D+H_2$, $D+H_3$, $D+H_4$ are hybrid reactor + LWR(U/Pu circulation) co-generation systems. Hybrid reactor co-generation system power plant prices are cheaper than fast reactor co-generation systems. OT is one pass LWR; D is U/Pu circulation LWR. H is the hybrid reactor, whose performance is illustrated in Table 4. [not reproduced]

China's thorium resources are abundant: surveyed reserves are over 200,000 tons. Developing hybrid reactors may effectively use thorium resources so that China's nuclear fuel resources will be expanded over three-fold.

Hybrid Reactors Are Safer Than Fast Reactors

First, hybrid reactors are a one-time critical device; second, the reactor after heat problems are fewer than the fast reactor's, the controlled fission hybrid reactor is safer than the LWR, fission rate is extremely low (each fusion in the cladding induces a fission number of <0.05), unloaded fuel fission produce is only 1/60 that of the LWR; third, in fluidized-bed combustion circulation nuclear fuel in the reactor can leak out during an emergency shutdown and there is the problem of melting inside the reactor; fourth, direct enriched hybrid reactor does not have a post-processing problem; fifth, when the hybrid reactor-satellite reactor co-generation system requires post-processing, all the waste elements in the satellite reactors can be concentrated in the hybrid reactor plant for processing.

Other Advantages

The hybrid has a number of advantages over the fast breeder reactor. For example, the hybrid reactor can produce isotopes of ^{239}Pu which can be more than 95.5 percent pure; it can build a tritium reactor; there is the possibility that it can become a way for final processing of wastes with long radioactive lives; it can construct a high-temperature heat source of more than 1000°C replacing high-temperature gas-cooled reactors and be used for coal gasification, production of hydrogen, and organic synthesis of methane, alcohol, and gasoline.

Another important function of hybrid reactors is that they act as an intermediate stage in the transition to pure fusion reactors and can be second-degree test reactors for pure fusion development to test materials and equipment, and accumulate design, construction and operational experience. Yet the fast reactor serving as a transitional reactor is completely independent and has no direct relationship to fusion development.

From the several points cited above it can be seen that the superiority of the hybrid reactor compared with the fast breeder reactor is clear. The issue that concerns everyone now is the feasibility of the hybrid reactor. With regard to this point, development of the fast reactor is naturally mature, prototype reactors are already connected to networks and transmitting electricity. For a hybrid reactor to develop to today's stage of the prototype fast reactor would take about 15 years. There are many engineering and technical problems that must be resolved in hybrid reactor development. However, construction of a hybrid reactor has already been resolved in principle, and at the same time, since in terms of engineering and technology it is based on the foundation of existing fission reactor and fusion reactor engineering research, there are no insuperable problems, and construction is possible; the problem is one of time. China's development of breeder reactors is to resolve the problem of energy shortage in the 21st century. Technological maturity is a necessary condition for introducing an energy source system, but it is not a complete condition. Whether or not it can, or to what degree can resolve China's energy shortage in the 21st century is the complete condition. From this angle, proceeding from the actual circumstances in China, China's development of breeder reactors by taking the path of hybrid reactors seems to be the best policy.

Developing Hybrid Reactors Is Important Challenge and Opportunity Facing China

It was mentioned above that although there are difficulties in developing hybrid reactors a feasible path has already been realized. Internationally, since there are great difficulties in developing pure fusion reactors, construction time may be longer than previously thought.

China has a foundation of 30 years of fast breeder reactor work, does not have accumulation of industrial plutonium, and development of fast breeder reactors would not resolve the long-range energy problem. Compared with the FBR, China's fusion research has two bases and a good foundation. China's path of developing nuclear energy need not take the crooked road of thermal reactor--fast reactor--fusion reactor. In the new technological revolution, we must be far-sighted, strengthen leadership, concentrate forces, and take the path of developing hybrid reactors. In this way we may later dominate. "The opportunity should not be lost, the time will not come again," we cannot let this opportunity pass us by.

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FIVE MORE NUCLEAR PLANTS ON CONSTRUCTION AGENDA

40130043 Beijing RENMIN RIBAO in Chinese 10 Jan 88 p 3

[Text] Beijing 8 Jan--After the Qinshan nuclear power plant in Zhejiang Province and the Daya Bay plant in Guangdong, China plans to build a batch of nuclear power projects. Feasibility studies for three nuclear power plants and two nuclear heat supply facilities at sites in Fujian, Hainan, Lanzhou, Qiqihar, and other places have been completed.

In cooperation with foreign firms, S&T personnel of the Beijing Nuclear Engineering Research and Design Institute have completed initial feasibility studies for a 900,000-kilowatt and a 600,000-kilowatt pressurized-water nuclear power plant for Fujian Province, a high-temperature, gas-cooled nuclear power plant for Hainan Island, and nuclear heating facilities for Lanzhou and Qiqihar.

In the past few years, this design and research institute--the best and biggest of its kind in China--has participated in a number of projects including the preliminary feasibility study on the second phase of the twin 600,000-kilowatt pressurized-water reactor project for the Qinshan nuclear power plant. They have also completed food irradiation facilities in Lanzhou, Nanjing, and other places and more than 30 nuclear science research projects and isotope experimental laboratories. They also did the initial design work on the power reactor fuel element reprocessing shop.

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BRIEFS

300MW HAINAN PROJECT--China plans to construct a 300,000-kilowatt nuclear power plant on the island of Hainan. The third nuclear power plant in China, the Hainan plant is one of several planned power facilities that will boost the island's generating capacity to 2 million kilowatts. [Text] [Shanghai WEN HUI BAO in Chinese 9 Jan 88 p 1] 40130043/12223

EXPERIMENTS ON ELECTRIC POWER FROM WAVES CONTINUING

40130046 Beijing GUANGMING RIBAO in Chinese 11 Jan 88 p 1

[Summary] China is accelerating its program to "look to the sea for energy" and today possesses the technological base to develop small-scale tidal power stations with an installed capacity ranging from hundreds to thousands of kilowatts. The research needed to generate electric power from wave action and tidal flow and from temperature and salinity differentials has made initial headway.

The technologically up-to-date experimental Jiangxia tidal power station was completed in 1985 in Wenling in Zhejiang Province. This station has five two-way, flow-through bulb-type turbines developed in China and has an installed capacity of 3,200 kilowatts. China now has eight tidal power stations in operation with a total installed capacity of more than 9,300 kilowatts.

Since the 1970's, China has conducted experiments involving six different types of wave-powered units. The Guangzhou Energy Institute developed a state-of-the-art wave-powered generator in 1985, 25 of which are now in use in Chinese waters.

In the use of temperature differential to generate power, China built an experimental facility in 1986 to explore the seawater thermal conversion technology of generating electricity. Successful experiments on 8-kilowatt tidal power generators have been conducted in Zhoushan, Zhejiang Province, and tests involving the application of salinity and density differentials to generate power have been carried out in Xi'an.

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